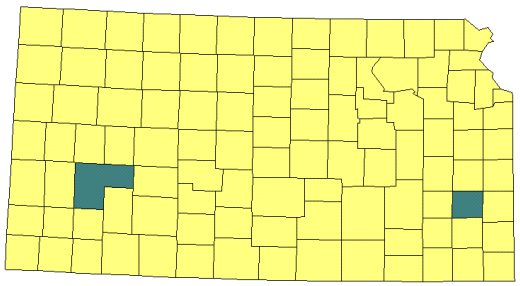
Improvement of Oil Recovery in Fluvial-Dominated Deltaic Reservoirs in Kansas -- Class I

University of Kansas



Morrow Sandstone — Stewart Field

@ >1,000 ft. — Finney County, KS

Cherokee Sandstone — Savonburg Field

@ >1,000 ft. — Allen County, Kansas

Pennsylvanian Age — Kansas Uplift

DE-FC22-93BC14957

Contract Period:
6/18/1993 to 9/30/1999

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Objective: The University of Kansas has combined with two oil operators to demonstrate the applications of current technologies for increasing oil recovery in Kansas. The demonstration sites are the Savonburg Field (Cherokee sandstone) and Stewart Field (Morrow sandstone).

Technologies Used: Reservoir modeling, numerical simulation, core analysis, petrophysical properties, interference test/tracer, pressure testing, permeability modification, infill drilling, waterflooding, and improved reservoir management.

Background: The University of Kansas geological and engineering groups, along with a group of operators, have demonstrated the applications of current technologies for increasing the recovery efficiency and economics in Cherokee and Morrow sandstone fluvial-dominated deltaic reservoirs in Kansas. Two field demonstration sites were selected - the Savonburg and Stewart fields. The projects include a broad range of technologies: (1) reservoir management, (2) polymer flooding, (3) in-situ permeability modification, and (4) infill drilling for bypassed mobile oil. The production problems include: (1) poor volumetric sweep due to reservoir heterogeneity, (2) clogging of injection wells with solids during waterflooding, and (3) poor waterflood sweep efficiency (4) lack of optimization of production through reservoir simulation and management.

Incremental Production: Waterflood optimization and reservoir management in the Savonburg Field have offset the production decline rate and have yielded estimated incremental oil of 31,000 barrels. Stewart Field is currently producing in excess of 100,000 barrels of oil per month. Production increase in the Stewart Field resulting from water injection is approximately 3,000 barrels of oil per day. Total incremental production for the Stewart Field is 1,634,782 BO through July1999.

Expected Benefits and Applications: Application of the air flotation process for water injection cleanup will be applicable to several fields that have common water injection problems. This technology will reduce well cleanup costs and lower operating costs. Optimizing the waterflood patterns and improving the injection water quality by installing an air flotation unit will be applicable in many fields. The project has demonstrated that proper reservoir management can significantly improve oil recovery.

Accomplishments: Engineering and geologic studies were carried out on the Savonburg Field. The studies identified areas of high potential for unrecovered mobile oil. An in-fill well was drilled and cored, which confirmed the results from these studies. Based on this work, well workover plans and waterflood pattern changes are being developed which target high potential areas. Waterflood water quality was studied and a water clean-up system incorporating air flotation was designed and installed in the field. Injection water quality has been improved significantly with a 90% decrease in solids content. The incremental production from Savonburg Field is estimated at 363,000 barrels of oil. Air flotation was successfully implemented as a method to improve water quality. Different techniques concerning wellbore cleanup were developed, and the technologies were transferred to local service companies for widespread use in the shallow slim-hole completed wells of eastern Kansas.
Engineering and geologic studies including the computer simulation of the Stewart Field have been accomplished. Primary production was history matched with the computer model. Simulation and study of polymer-augmented waterflooding indicated that this process would not be economical on the Stewart Field. Several alternative waterflood designs were examined with the simulator. Based on the simulations, waterflooding appears to be technically and economically attractive. Laboratory studies have indicated that the reservoir has some sensitivity to water. Based on these studies, a waterflood was designed and implemented in the Stewart Field. A reservoir management strategy has been developed which incorporates continued multidisciplinary analysis of waterflood data and updating the computer model in an attempt to optimize secondary recovery. The Stewart Field has responded favorably to water injection with oil production increasing from less than 300 BOPD to over 3150 BOPD. Incremental production from Stewart Field from March 1996 to July 1999 is 1.64 million barrels of oil and the ultimate recovery is estimated to be 4 million barrels. The Stewart Field project was awarded, "Best Advanced Recovery Project in the Mid-Continent" by Hart's Oil & Gas World for 1995. Lowered operating costs for production water treatment. Improved quality of injected and produced water. Optimized waterflood oil recovery through improved reservoir management techniques in the Stewart Field. General methodologies were developed and disseminated for the evaluation and exploitation of mature oil reservoirs.

Publications: (1) Reynolds, R.R., G.P. Willhite, M. Jensen, 1997. "Implementation and Monitoring of the Stewart Field Waterflood": Proceedings of the Twelfth Oil Recovery Conference, Wichita, Kansas, Tertiary Oil Recovery Project, The University of Kansas,

Contribution 14, Lawrence, Kansas. (2) Barnett, B., 1997. "Savonburg Project progress report": Proceedings of the Twelfth Oil Recovery Conference, Wichita, Kansas, Tertiary Oil Recovery Project, The University of Kansas, Contribution 14, Lawrence, Kansas. (3) Michnick, M., 1997. "Problems in the use of air flotation for cleaning produced water": Proceedings of the Twelfth Oil Recovery Conference, Wichita, Kansas, Tertiary Oil Recovery Project, The University of Kansas, Contribution 14, Lawrence, Kansas. (4) A paper published on the Stewart Field project in the "PTTC/World Oil Case Study Digest." (5) Articles on both the Stewart and Savonburg projects were highlighted in a North Mid-continent PTTC newsletter in the Spring of 1999. (6) Reynolds, R. R., D. W. Green, G. Paul Willhite, M. J. Michnick and D. McCune, 1999, "Improved Oil Recovery in fluvial-dominated deltaic reservoirs of Kansas": The Class ACT, DOE Newsletter, Vol. 5, No. 1, Winter 1999. (7) Green, D. W., G. P. Willhite, A. Walton, R. Reynolds, M. Michnick, L. Watney, D. McCune, 1999, "Improved Oil Recovery In Fluvial Dominated Deltaic Reservoirs of Kansas - Near Term": Annual Report June 17, 1997 to June 17, 1998, University of Kansas, Center for research Inc. Lawrence, Kansas; January 1999, DOE/BC/14957-23 (OSTI_ID: 2715). (8) Reynolds, R. 1999. "Waterflood in Kansas field should boost recovery by five million bbl", Petroleum Technology Digest, September 1999, p. 1-4.

Recent/Upcoming Technology Transfer Events: : (1) Bill Guy , “Log Analysis Case Studies of Many Kansas Formations”: PTTC Modern Techniques in Wireline Logging Workshop, November 19, 1998, Wichita, Kansas. (2) A presentation on the Stewart Field project was made at the North American Prospect Expo (NAPE) in Houston, TX on January 27-28, 1999. (3) Presentation made at the Society of Independent Earth Scientists (SIPES) 1999 annual convention and seminar in Wichita, KS on March 10-12, 1999. (4) Sizemore, J., “Maximizing oil recovery rates in the Stewart Field waterflood”, 13th Tertiary Oil Recovery Conference, Wichita, KS, March 17-18, 1999. (5) Michnick, M. J. and B. Barnett, “Field experience in obtaining high quality injection water using air flotation in the Savonburg Field”, 13th Tertiary Oil Recovery Conference, Wichita, KS, March 17-18, 1999. (6) Case study presentations on both the Stewart and Savonburg projects were presented at a North Midcontinent PTTC technology workshop on waterflooding during the summer of 1999.Green, D, “Improved Oil Recovery in fluvial Dominated Deltaic Reservoirs of Kansas”, DOE Oil & Gas Conference, June 28-30, 1999, Dallas, TX. (7) Presentation at KIOGA meeting, Wichita, KS, August 27-29, 2000.

Project Status: Project completed December 1999. Final report published June 2000.